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A Review on the Identification and Classification of Activities for the Purpose of Tracking Objects in Video Surveillance

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ABSTRACT

An increasing number of academics are becoming interested in the field of image processing since object tracking in video surveillance is a significant application and a growing subject of research in the field of technique known as video tracking is one that involves the utilization of a camera in order to find a moving object or many moving things throughout the course of time. As a result of its key qualities, video surveillance serves a variety of functions, including but not limited to human-computer interactions, security and surveillance, video communication, traffic management, and public areas such as airports, underground stations, and large-scale events, amongst others. Keeping track of a target in a congested area is still a difficult video surveillance task. The processing framework for video surveillance is completed by a sequential flow that includes the detection of moving objects, their classification, tracking, and behavior identification. This study examines tracking techniques, classifies them into many categories, and concentrates on significant and practical tracking techniques. This paper discusses several tracking systems, including active contour-based, area-based, and others, along with their advantages and disadvantages. Various tracking techniques are discussed along with thorough descriptions. Finally, researchers present an overview of potential research areas after reviewing general tactics and a scan of the literature on various methodologies.

Key Words: Object Detection, Object Representation, Object Tracking, Motion Segmentation, Video Surveillance.

1. INTRODUCTION

Image processing is a sort of processing in which the input is an image, such as a frame from a photograph or video, and the output may be parameters or characteristics related with the image. Image processing may be thought of as a subset of image processing. Strategies for integrating, understanding, and presenting images are the focus of the study of computer vision, which is a subfield of computer science. It is the practice of keeping a watch on people's activities, behaviors, and other dynamic data with the purpose of guiding, protecting, and influencing them. The name "surveillance" refers to the mechanism by which this is done. The practice of employing a camera to establish the location of a moving item is referred to as video tracking. When broken down into its most basic form, tracking may be defined as the act of connecting target objects in a sequence of video frames. When the tracked object travels at a quicker pace than the frame rate or when it changes direction over time, problems arise. In particular, this is the case. A sequential series of object identification, object tracking, object detection, and object behavior is what brings the process framework of tracking to a successful conclusion or conclusion.

Global worry has been sparked by the intelligent criminal system, terrorist assaults, and growing security-related problems. The manual analysis method has several drawbacks, including being expensive, labor-intensive, error-prone, and often lacking sufficient human resources to continuously monitor signals [1]. It is exceedingly difficult to provide 24x7 monitoring due to time constraints, resource shortages, and technological advancements in criminal attacks. As a consequence, the chance for a clever and intelligent-based video surveillance system is knocked. As a result of this, there are now more prospects in the video surveillance sector. The 2001 Super Bowl saw the successful application of facial recognition technology for government enforcement monitoring. Almost 100,000 spectators entered the stadium in Tampa, Florida, to watch the Super Bowl in January 2001, and local police officers captured their faces on camera. After that, an electronic comparison of these face photos was made with a database of criminal computers. Marcus Nieto claims CCTV surveillance systems are widely used by local government agencies in California, and its main purpose is property protection as opposed to public movement tracking [2]. According to Dean Drako's (2014) cloud video surveillance report operational improvement within the next two years is video surveillance's primary goal, aside from security issues [3]. One of the key benefits of a cloud-managed video surveillance system is that it provides off-site redundancy as well as the ability to alter storage capacity inside the system. Axis Communications reports that the use of IP-based video systems has a significant negative influence on other applications than security [4]. Merchandising and operations have experienced a favorable influence, mostly from stores who utilize the same.

With regard to computer vision and pattern recognition, one of the most important aspects is the management of object tracking in video surveillance. Motion segmentation, object tracking, and classification are the three primary phases that are often included in the architecture for classification. For the purpose of producing precise estimations, the Kalman Filter is a strong tool that makes use of data that have been observed over a period of time.

There are a wide variety of applications for it, including control, navigation, computer vision, and other domains. These are only a few of the many possible applications. The ability to predict the future location of an item, the reduction of noise, and the tracking of both single and numerous items are some of the capacities that the Kalman filter possesses that are considered to be among the most essential characteristics. The data shown in demonstrates that the Kalman filter is even capable of monitoring many moving objects in an effective manner, even in circumstances that are challenging and sophisticated [5]. It is possible to apply the particle filter to any state-space model, and moreover, it simplifies the understanding of the typical Kalman filter procedures [6]. An analysis of the optimal and suboptimal Bayesian algorithms, with the particle filter acting as the major centre of attention throughout the course of this investigation. A variety of other variations, including SIR, ASIR, and RPF, were also introduced in addition to the particle filter. An technique to multi-camera tracking that is completely automated was developed in line with the suggestion that Mittal and Davis initially presented [7].

An technique that is based on regions is utilized in this method in order to properly address occlusions that are brought about by the positioning of dense objects. A ground-breaking system that permits real-time pedestrian recognition and tracking from a moving vehicle was disclosed by J. Ge, Y. Luo, and G. Tei in 2009 [8]. This technology also incorporates night vision capabilities. There are three different components that make up the system: tracking, object categorization, and ROI generation/generation. Each individual module makes use of visual characteristics in order to differentiate things from the crowded backdrop. When it comes to dealing with combinations of numerous picture circumstances, it has been shown that a single feature extractor is not successful. An ensemble technique is given as a solution to this problem. The goal of this method is to establish collaborative approaches that are capable of overcoming the limits of individual component classifiers. In the following sections we will discuss a variety of approaches to object tracking that are currently available [9].

The following is the composition of the paper's structure. Object representation and feature descriptors are the primary topics of discussion in Sections II and III. The motion segmentation analysis is covered in Section IV. The following is a comprehensive study that discusses the various strategies, including both their good and bad elements. The categorization of objects with numerous types, the monitoring of categorization into separate categories, and the comprehensive analysis of connected work are all explained in the following sections. In conclusion, Following the description of the problem domain, we proceed to validate the performance. then presenting our solution, and then drawing a conclusion.

2. THE REPRESENTATION OF OBJECTS

In this context, an object refers to an entity of interest that we are required to track, such as birds, zoo or woodland animals, airplanes, traffic control vehicles, and people walking at different speeds. The form and size of an object can be used to represent it. The object's depiction is seen in Fig. (1), [10].

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A. Highlights

A collection of points that make up a tiny region of interest and are utilized for small area tracking can be used to characterize an item. There is also the possibility of representing an item as a single point, which is referred to as a person's centroid.

B. Forms that are geometric

This works best with basic, stiff things. For non-rigid object tracking, the form of the object can alternatively be represented as an ellipse or rectangle.

C. The outline of an object

An object's outline is represented by the region inside the contour. A contour depicts an object's edge. Both silhouette and contour are employed in intricate, non-rigid form tracking.

D. Skeletal Structure

Modeling stiff and articulated things is done with the object skeleton. By using the medial axis transform, it may be extracted from the object silhouette. The distance to the boundary is shown on the medial axis. In a region R, each point P locates its closest neighbor along the boundary, and each point is part of the area's medial axis. It is employed in modeling both rigid and articulated objects.

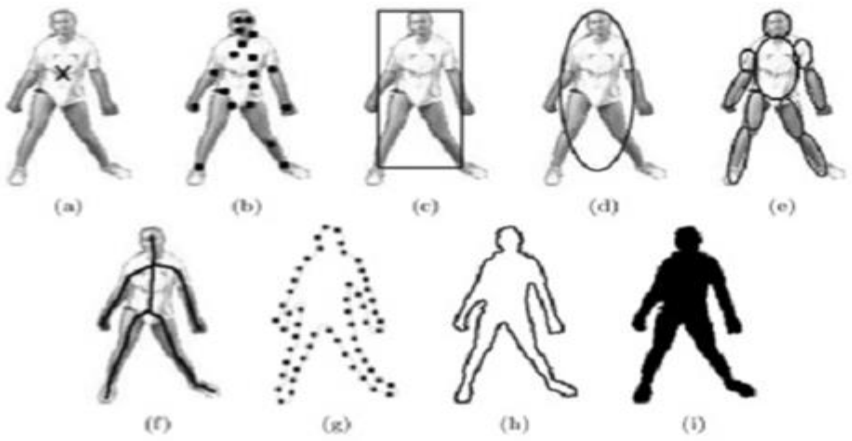

Figure 1 Object representations (a) The centroid, (b) many locations, (c) a rectangular patch, (d) an elliptical patch, and (e) multiple patches that are based on parts of your body f) the skeleton of the item, g) the whole contour of the object, h) the control points on the contour of the object, and i) the silhouette of the object [10].

For tracking, an object's visual characteristics and form representation are integrated. The following is a list of frequently used appearance features:

E. Model of probability density appearance

Gaussian mixture models and histograms employ this concept. It is possible to calculate the probability density of a picture based on its regions, including its color, texture, etc.

F. Recognition of objects in multiple views

This method uses a sequence of views to represent an item; each view includes details about a narrow range of viewing conditions. There are two steps involved in finishing the representation: the first is grouping sample photographs together to depict angles from which an object can be viewed. The second aspect is that members of the group are spread out in a broad variety of locations in order to develop model view characteristics.

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G. Models

A template that contains information on both the appearance and the placement of a form is called a geometric shape. Its primary function is object tracking

3. FEATURE DESCRIPTORS

Simply described, a feature in image processing is a piece of information that is important for separating apart the computing tasks associated with a particular application. Features might be certain structures found in the image, such as textures, edges, points, and objects. Two or more features must be retrieved in complicated settings where a single feature type may not provide enough information from the visual data. The majority of color object tracking systems are resilient to fluctuations in lightning and rely on the item's HSI color. Using RGB features improves the classification accuracy of color feature vectors; however, these features are subject to lightning changes. Local feature descriptors are extracted using the Scale Invariant Feature Transform (SIFT). The strong local invariant feature descriptor SIFT was primarily created for grayscale pictures [11]. Compared to color descriptors, edge characteristics are shown to be less susceptible to variations in light. Texture characteristics can also be exploited; however, doing so will cost extra processing steps and computing time. Additional feature descriptors include, amongst others, biological properties and optical flow. There are also a number of other description options. In order to differentiate between things in the foreground and those in the background, characteristics are employed [12].

A. Colored

In image processing, color is represented using the RGB color feature space, which stands for red, green, and blue. The RGB space makes use of an object tracking system that is based on particle filters and combines attributes related to color and form [13]. Surface reflectance characteristics and spectral power distribution are the two physical factors that have an effect on color of a material. In the HSV space, hue, saturation (also known as lightness), and value (often known as brightness) are the three components [14]. In addition to being a uniform color scheme, HSV space is also quite sensitive to noise.

B. Corners

Image intensity variations are detected via edge detection. The edges of features are less susceptible to changes in light than color explains that it is part of an algorithm based on a three-dimensional model that selects features using edge points. Edge features are used to track an object's boundaries [15].

C. The texture

It is employed for segmenting images with characteristics like regularity and smoothness, as well as surface variation. Information about the spatial arrangement of colors is provided by image texture. It is used in two categories: boundary based and region based. One of the best-known pattern analyses for grayscale photos is the local binary pattern (LBP) texture [16]. CAM Shift is one of the many tracking based algorithms that relies on LBP texture [17]. Other tracking-based algorithms also use LBP texture.

D. Instant

Using a moment-based area feature, one may identify objects and ascertain a stranger's gender based on their gait.

4. MOTION SEGMENTATION

A computer vision technique called object detection looks for instances of moving things, including people, cars, animals, birds, and other items. One of the first phases of object tracking is object detection. Face and pedestrian detection are examples of state-of-the-art object detection techniques. Object recognition in computer vision refers to locating the intended host. Combining an object's characteristics with its model of an object yields recognition. The number of things in the image, the scene consistency, the potential for occlusion, as seen in Fig. (2), and other factors all affect how difficult it is to recognize objects.

Motion detection is often a component of a stationary camera video surveillance system. Here are some descriptions of a few motion segmentation techniques:

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A. Subtraction of Background

One popular method for identifying moving objects from a still image is background removal. By comparing the current frame to the backdrop frame, one may identify objects. Recursive and non-recursive procedures are the two groups into which background modeling falls. The recursive approach for background estimation encompasses nonparametric models, linear predictive filters, median filters, and frame differencing. The median filter, Kalman filter, and Gaussian mixture form the foundation of the recursive approach.

Figure 2. Individuals experiencing partial occlusions

An efficient method that is based on a disturbance map was created by Halevi and Weinshall [18]. This method is formed by linearly subtracting the temporal average of the frames that came before the current frame from the frame that is now being used. For the purpose of generating tracking data, both stationary and moving cameras have been utilized. When photos are processed at the pixel, region, and frame levels, the Wallflower approach that proposed in 1999 to handle challenges that emerge at several spatial scales [19]. This method was developed to address these kind of issues. A camera-based automated system that uses the Kalman filter for tracking and Learning Vector Quantization (LVQ) for identifying pedestrians and cyclists was reported by Heikkila and Silven [20]. This system was able to categorize both types of individuals. In the year 2003, research was still being conducted in the field of automated tracking and intrusion detection in surveillance systems [21]. When a tracking system that combines backdrop generation and removal is used with a PTZ camera, it is possible for variations in global intensity to have an effect on the system. For the purpose of identifying the object, it is necessary to update the prepared photographs that are located in the newly created region whenever a camera view is altered. H. Galoogahi presented a method that makes use of forward and backward matching in order to handle events such as the merger and splitting of objects. primary emphasis on monitoring a group's movements, including their entrance, fusion, division, and departure, as well as their correspondence with the collection of things [22]. The tracking operation is conducted continuously using the RGB histogram. The fundamental component of background removal is background modeling, which is best identified using the mean and median filters. The background picture of a film was obtained by R Zhang and J Ding using a median filter, and moving objects were identified and tracked using an adaptive background subtraction technique [23]. After using a morphological filtering technique to eliminate background noise and produce a crisp, clear picture, contour projection analysis and shape analysis are coupled to eliminate object shadows [24]. Human motion tracking and detection for real-time security systems was developed in a 2013 research report [25].

B. Differencing in Time

The frame difference is the foundation of temporal differencing methodology. This approach finds the moving areas in a video stream by comparing the differences between consecutive frames. While this is computationally efficient and very adaptable to dynamic situations, it often performs poorly when it comes to obtaining the whole outlines of some kinds of moving objects. Using the temporal difference approach can also cause tiny holes to emerge in moving objects; a resolution for this is given in [26].

C. Optical Circulation

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There is a technique known as optical flow that is based on vectors and employs object point matching across a large number of frames to estimate motion in video pictures. This is the name of the vector field that describes the rate at which pixels move along an image progression's progression. Through the utilization of optical flow, presents a technique that may be utilized to identify obstacles in a mobile robot environment [27]. This approach involves isolating the obstacles from the ground floor in an image series. In order to determine whether or not there was any degree of movement in the pixels of the video picture, the algorithm for optical flow was utilized. An technique that is based on optical flow field and self-adaptive threshold segmentation is suggested in as a means of properly detecting the area of a moving object [28].

5. OBJECT CLASSIFICATION

The process of classifying involves grouping specific elements, such as objects, patterns, pixels, picture areas, etc., according to how similar they are to the group's description. Video surveillance object categorization is accomplished through a variety of ways, the most frequent of which are classifications based on shape, motion, color, and texture.

A. Shape-Based Categorization

Shape-based categorization does not take structural analysis into account; it just considers an object's shape. Objects can be classified based on the shape of the extracted portions (boxes, blobs, etc.) that contain motion. Investigates the analysis of different shape characteristics using performance metrics and accuracy. A technique for tracking people in crowded scenes with occlusion was given by T. Zhao and R. Nevatia. It involved using human-form models in addition to camera models. Combining a shape model with the mean-shift tracking extension and a Bayesian framework provides a logical method for concurrently tracking and detecting people. In comparison to other classification techniques, shape-based classification has a reasonable level of accuracy and a very short processing time, according to [26].

B. Classification Based on Motion

Motion-based classification provides a strong approach to classification and helps lessen the dependence on the objects' spatial primitives. It finds it difficult to recognize a stationary object, but it does not require preexisting pattern templates. Motion-based classification is a computationally costly method of classification, despite its moderate accuracy. A method for tracking and identifying objects based on vision was proposed by S. Johnsen and A. Tews [28]. This works well across a variety of objects in different weather situations and can handle occlusions.

C. Categorization Based on Color

The most effective technique to show how similar two color images are is to express them using color space or color features. Comparatively speaking to other feature elements, color is determined to be rather stable and simple to acquire. Color-based searches are the most effective and straightforward in content-based picture retrieval systems [14]. In the year 2010, a vision-based moving object tracking system that makes use of wireless surveillance and color image segmentation was described. The system tracks objects by using color histograms with background removal. Bhattacharya coefficients were also used to eliminate object occlusions. Color-based categorization has great computational time and accuracy, according to.

D. The Classification of Textures

One of the main goals of texture classification is to assign an unknown picture to a known texture class. The main challenge in the presence of many classifiers is to create efficient feature extraction from textured images. The process of texture-based categorization may be broken down into two distinct stages: the learning phase and the recognition phase. Support vector machines (SVM) are used in texture-based approaches, such as histograms of oriented gradient (HOG), in order to detect human regions through the utilization of high-dimensional features that are dependent on edges. According to, it results in higher accuracy quality at the cost of longer computation times.

6. TRACKING OBJECTS

Tracking is the act of following a moving object. To put it simply, tracking is the process of determining an object's path in the picture plane as it travels across a scene. As an alternative, a tracker gives the monitored objects in several

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video frames constant labels. An object's area, orientation, and shape are examples of object-centric information that a tracker can offer based on the tracking domain, technique, and algorithm. Once discovered, the next step in the video surveillance process involves tracking objects from one frame to the next. Because of their complicated forms, mobility, and non-rigid nature, as well as variations in scene lighting and partial or complete item occlusions, tracking objects may be challenging. A basic limitation, such as the object's motion being smooth and devoid of sudden shifts, or existing information regarding the quantity, size, shape, and appearance of things, might simplify these. There are many techniques available for object tracking, including dynamic Bayesian networks, the geodesic approach, Kalman filters, blob tracking, kernel-based tracking, feature matching, and the Condensation algorithm. In tracking, there are four main categories: region-based tracking, active-contour-based tracking, feature-based tracking, and model-based tracking.

A. The Region-Based Tracking

The methodology tracks moving objects based on how the picture parts deviate from one another. In our understanding, a cross-correlation function is used to identify each car blob in the vehicle detection example. Usually, we detect motion areas by removing the backdrop from the current image using background subtraction. In his work on real-time traffic monitoring systems for moving vehicle detection, M. Kilger [28] employed the same technique. Cars partially obscure one another in heavy traffic, making it challenging to identify the cars. Several research approaches model the human body and backdrop scene using a Gaussian distribution of pixel values. Finding a person's physical components, including their hands and head, is essential. The challenge of a single person utilizing a fixed camera was solved in real time by C. R. Wren and Ali with their pfinder (person finder) system [26]. To handle shadows and erratic color cues, gradient information derived from the background subtraction approach is combined with color information. We use color cues during occlusion to aid in distinguishing between the items. The tracking mechanism presented in the article is color-based, as opposed to utilizing the human body approach [27]. The visual components change depending on the person's style of dress and what they are wearing. In certain cases, such as when two objects share a similar outfit, the tracker will not be able to follow them together.

B. Tracking Using Active Contour Based

Using bounding contours to describe the outlines of moving objects, the active contour-based tracking approach tracks them and updates them dynamically. The computational complexity was lower in contrast to the region-based detection method. In order to identify a pedestrian, Paper integrates motion and appearance data [29]. You can extract motion information from a sequence of photos. These straightforward filters have the advantage of having a shorter calculation time than others. Employs a counter-based technique in which an object's form is preserved during occlusion by keeping an online built shape prior. The protection of drivers and the prevention of accidents that are caused by dim rear lights is accomplished through the utilization of a one-of-a-kind image processing algorithm that deals with vehicle rear-lamp pairs for the purposes of identification and tracking. The lights are paired, symmetric, and monitored by a Kalman filter. This is accomplished by the utilization of a color cross-correlation symmetry analysis.

C. Tracking Based on Features

This technique uses feature matching, clustering, and element extraction to target the identification and tracking of pictures. It monitors the object's distinct lines or points, for example, as sub features. Adding a common motion restriction can effectively increase the efficacy of feature-based tracking. It is possible that we may partially resolve the problem of partial occlusion, which will result in some of the sub-features remaining visible. Within the context of Polana and Nelson demonstrate how bottom-up processing may be utilized to identify activities that include repeated motion, such as walking [29]. This motion pattern serves as a potent signal for identifying, categorizing, and normalizing the actor. When strict normalization is not possible, activity recognition is unsuccessful.

7. PROBLEM DOMAIN AND FUTURE WORK

The object tracking section provides a full explanation of how difficulty rises with changes in form, size, orientation, and other related characteristics. Obstacles include segmentation mistakes, tracking intricate objects (faces, faces, etc.), changes in lightning conditions, and shadows. There's a good chance that other items will cause an object tracking disruption. Tensor voting is a unified computational framework that has been presented for the purpose of

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managing numerous structures and the relationships between them while working with a data set that is noisy and irregularly clustered. The method in question is non-iterative and it is capable of handling surface and curve inference from a point in either two or three dimensions [29]. The approach of tensor voting is a trustworthy method that is not constrained by surface topological conditions. Fig. (3) provides an explanation of the tracking process, which begins with object detection and recognition and continues with object tracking. For the purpose of recording the film, which represents the input, a static camera was utilized. Step by step, the procedure begins with the identification of the object of interest, followed by the extraction of the foreground through the utilization of the background subtraction technique, and finally the provision of a bounding box. Color is used to model each pixel, which is also referred to as a tensor, and voting is carried out based on the scale of the elements. The tensor that was formed encompasses information on the amplitude and direction of the current. This information is sent on as an input to the Gaussian component that is responsible for comparing the color model in linked frames. In the event that the comparison is successful, the item is successfully tracked; nevertheless, if the matching is not the same, a new object has entered the scene where it was previously present.

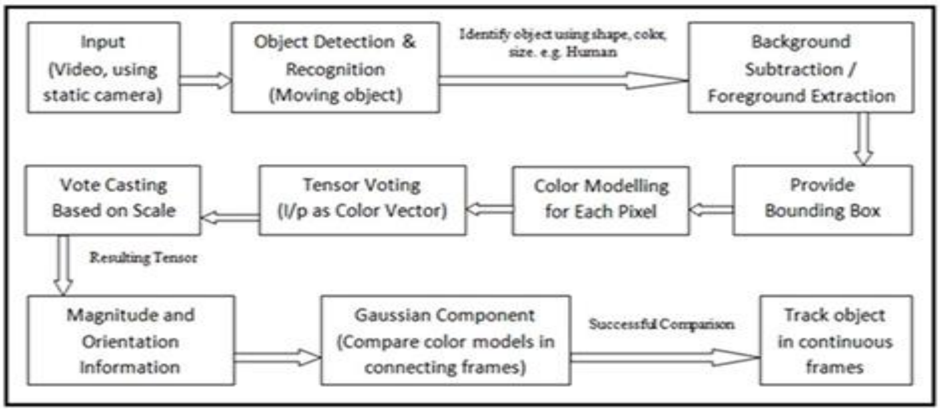

Figure 3. Tensor voting framework presented in the form of a block diagram for object tracking

8. CONCLUSION

We began this study by discussing the use of significant feature descriptors in the representation of objects. We went into great length on the tracking process, covering everything from object tracking to temporal differencing, optical flow, and background removal in detection and recognition. The next sections will discuss the object classification approach, which includes a number of different categories and object tracking kinds, including region-based, active contour-based, and feature-based object tracking among others. Our further study will concentrate on creating a color based tracking system that, by modeling colored clothes using a tensor voting framework, can successfully handle both partial and total occlusion.

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